Risk Factors for Delayed Immunization among Children in an HMO

ABSTRACT

Objectives. Improving the timely delivery of childhood immunizations has become a national imperative. This study aimed to identify nonfinancial predictors of delayed immunization among patients with good financial access to preventive care.

Methods. This prospective cohort study used telephone interviews and a computerized immunization tracking system to evaluate 13-month-old children (n = 530) in a regional group-model health maintenance organization.

Results. More than one third of parents interviewed did not know when the next immunization was due. Thirteen percent were late for the measles-mumps-rubella immunization, recommended at 15 months of age, by 90 days or more. Independent predictors of delayed immunization included having a larger number of children (odds ratio [OR] = 1.4, $P < .01$), not having a regular doctor (OR = 2.9, $P < .05$), not knowing when the shot was due (OR = 2.0, $P < .01$), and not worrying about the risks of shots (OR = 1.4, $P < .05$).

Conclusions. Financial access alone does not guarantee timely childhood immunization. In managed care settings, which may cover increasing numbers of children under health care reform, interventions are needed to better inform parents of when immunizations are due. (*Am J Public Health.* 1994;84:1621–1625)

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Introduction

More than one third of US children have not been appropriately immunized by the second birthday.[1] Delayed immunization is a major public health problem that has been associated with measles epidemics in recent years.[2] Better financial access to preventive care is a necessary but not sufficient condition for timely immunization.[3–6]

Improving immunization delivery will require a better understanding of nonfinancial reasons for delay. Previous studies have not been able to prospectively evaluate parent beliefs while controlling for financial access.[7–9] In this prospective study of children with good financial access to preventive care, we evaluated (1) the rate of delayed immunization; (2) the influences of nonfinancial risk factors; and (3) the accuracy of existing computerized information as a basis for identifying high-risk children for advance outreach efforts.

Method

Study Design

Parents of 13-month-olds were interviewed by telephone. Each child was then followed for at least 5 months via a computerized immunization tracking system. The system was initiated at the Northern California Kaiser Permanente Medical Care Program (KPMCP) in the winter of 1991 and included any child immunized at any of 13 clinics on-line at the start of this study. The measles-mumps-rubella (MMR) immunization was used as the main outcome measure because it is the first immunization due in the second year of life, when children are most likely to miss immunizations. The immunization was considered delayed if given more than 90 days after the due date.[10,11]

Study Population

KPMCP is a group-model health maintenance organization (HMO) that covers approximately 700 000 children in a geographic region approximately 250 miles in diameter. Most members receive health insurance as an employment benefit. Immunizations are covered in full, although some members must copay up to $15 for well-child care visits.

Between March and July of 1992, 6696 children seen in the KPMCP clinics served by the immunization tracking system turned 13 months old. Telephone interviews were attempted with 831 randomly selected families. Families were ineligible if the parents did not speak English, Spanish, or Cantonese (n = 10); the telephone number was wrong or had been disconnected (n = 52); they reported not using KPMCP, usually because they had a second form of insurance coverage (n = 61); or the child experienced a gap in KPMCP insurance coverage between 13 and 18 months of age (n = 103).

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TABLE 1—Demographic and Family Organization Characteristics of Families of 13-Month-Olds (n = 530) and Associations with Delayed Immunization: Northern California Kaiser Permanente Medical Care Program, 1992

	No.[a] (%)	Relative Risk of Delayed Immunization[b]	95% CI	P[c]
Demographics				
Race/ethnicity				
White	265 (50)	...	...	...
Latino	99 (19)	1.2	0.6, 2.4	NS
Asian	90 (17)	1.8	1.0, 3.2	NS
Black	68 (13)	2.1	1.2, 3.8	.03
Other or unspecified	8 (1)	...	...	...
Father's education				.10
Less than high school	39 (7)	1.9	0.8, 4.2	...
High school graduate	148 (28)	1.5	0.9, 2.8	...
Some college	156 (29)	1.4	0.8, 2.5	...
College graduate or more	186 (36)	...	...	...
Annual household income				NS
< $30 000	133 (27)	1.6	0.8, 3.2	...
$30 000–$50 000	206 (42)	1.9	1.0, 3.6	...
> $50 000	149 (30)	...	...	...
Both parents employed[d]	322 (61)	0.8	0.5, 1.2	NS
Family organization				
No. of children				.007
1	222 (42)	...	...	...
2	184 (35)	1.0	0.6, 1.9	...
≥3	124 (24)	2.2	1.3, 3.7	...
Single-parent family	50 (9)	0.8	0.3, 1.8	NS
Years of residence at current address				
<1 y	91 (17)	1.3	0.8, 2.1	NS
1–3	200 (38)	1.1	0.7, 1.7	NS
>3	238 (45)	...	...	...

Note. CI = confidence interval; NS = not significant.
[a]Numbers may not sum to 530 owing to missing values. No more than 3% of data in any category were missing, except for income, in which 8% of data were missing.
[b]Relative risk is expressed in comparison with the baseline categories: White, college graduate or more, more than $50 000 annual household income, one child, one parent employed, two-parent family, and more than 3 years' residence at current address.
[c]The chi-square test was used for categorical variables. The Wilcoxon rank-sum test was used for ordinal variables (father's education, annual household income, and number of children in family).
[d]For one-parent households, this variable was scored "yes" if the parent was employed.

Telephone Survey

A 15-minute, 33-question telephone survey was conducted in English, Spanish, or Cantonese by six experienced interviewers. It covered demographic characteristics, family organization, health care system variables, and vaccine knowledge and attitudes. Family organization questions included numbers of children and adults in the household and how many years the family had lived at its present address. Health care system questions covered experiences at the last visit for well-child care and whether the child had a regular doctor or nurse-practitioner at KPMCP.

For vaccine knowledge and attitudes, parents were asked when they expected the child's next well-child checkup, when they expected the next shot, whether the child or any of the family's other children had ever had a worrisome reaction to a shot, and whether the child had ever been more than a month late for a shot. Parents were asked how much they worried about the risks of shots, how much they would worry if the child were not up to date on shots, and whether the parent had ever hesitated to have the child get a shot. (A copy of the survey instrument is available from the authors.)

A follow-up survey was conducted for children without an immunization tracking system record of an MMR by 18 months of age. For 13 of these children, the parent reported and chart review confirmed that the MMR immunization had been given, usually at a KPMCP facility that was not yet part of the immunization tracking system. The computerized data were corrected prior to analysis.

Statistical Analysis

In the bivariate analysis the chi-square test (with Yates' continuity correction for 2×2 tables) was used for categorical variables, the Wilcoxon rank-sum test was used for ordinal variables, and the Spearman correlation coefficient was used for associations between ordinal variables. Multivariate analysis was performed with logistic regression procedures in SAS (SAS Institute, Inc, Cary, NC).

Results

Of the 605 eligible families, 530 (88%) completed interviews. Sixty-eight were unreachable after repeated attempts, and 7 declined to be interviewed.

Predictor Variables

Table 1 shows the demographic and family organization characteristics of the study population. In terms of health care system variables, almost all parents (96%) said their child had a regular primary care provider at KPMCP. Most (53%) had no copayment for well-child visits; 43% paid between $1 and $5. Forty-five percent of parents had missed or rescheduled work to bring their child to his or her last well-child visit. A plurality of parents (45%) had had the last well-child visit scheduled between 1 and 2 months in advance, 51% had waited less than 15 minutes to see the primary care provider, and 59% had spent between 1 and 2 hours on the round trip to the appointment, including transit time.

Table 2 shows parental knowledge and attitudes about immunization. Parents were asked when they expected their child's next well-child appointment and next shot. Answers that fell before the child's 16-month birthday were scored as correct. It is noteworthy that 36% of the parents in this study did not know when their child's next shot was due; this answer was highly correlated with not knowing when the next well-child visit was due ($P < .001$).

Delayed Immunization Rates and Predictors of Delay

Two thirds of the children in the study group received their MMR vaccinations within 30 days of the due date. However, 16% were late for the vaccination by 60 days or more, and 13% were late by 90 days or more. The rate of delayed immunization at 90 days was higher among ineligible and unreachable families (21%) than among the study group.

The baseline telephone interview was not intended to change behavior, but it could have influenced study group families to seek more timely immunization. After children with gaps in KPMCP insurance between 13 and 18 months of age (for whom the immunization tracking system might have incomplete records) were excluded, there were 530 families in the study group, 645 in the attempted interview group, and 4448 in the control group not selected for interview attempts. The study group had a lower rate of delayed immunization (13%) than the control group (19%; $P < .001$), but this comparison is biased by the inability to exclude ineligible and unreachable patients from the control group. The rate of delayed immunization among all 645 families in the attempted interview group (16%) was lower but not significantly different from that of the control group ($P = .08$).

Univariate analysis of predictors. Black race was correlated with delayed immunization (Table 1): 21% of Black children, compared with 10% of White children, were late by 90 days or more ($P < .05$). Income, education, and language spoken at home were not significantly associated with immunization delay. Families with more children were at higher risk for delayed immunization ($P < .01$).

Unexpectedly, parents who reported having had the previous appointment scheduled more than 2 months in advance had lower rates of delayed immunization than parents who had the appointment scheduled sooner ($P < .05$). Having had the previous appointment scheduled farther in advance may indicate better organizational skills on the part of parents rather than a longer wait for appointments. The amount of copayment was not associated with delayed immunization.

Most attitudes toward vaccines were not associated with delayed immunization (Table 2). Paradoxically, the more the parent worried about the risks of vaccines, the lower the likelihood of delayed immunization ($P < .05$). Not knowing when the next shot was due ($P < .001$) was strongly correlated with delayed immunization. It should be noted that 15-month-olds are eligible to receive the MMR immunization on time even if they have been late for previous immunizations. Despite this fact, having been late for a previous shot by the parent's report was also a strong predictor of delayed MMR immunization ($P < .001$).

Multivariate analysis of predictors. Variables associated with delayed immunization at a level of $P < .10$ were included in a logistic regression model (Table 3). Families with more children, those who did not identify a regular doctor, those who did not know when the shot was due, and those who worried less about the risks of shots were at significantly increased risk for delayed immunization. After adjusting for these other factors, Black race was no longer a significant predictor of delayed immunization. Having been late for a previous immunization was excluded from the final model because its similarity to the outcome of interest tended to reduce the explanatory power of other predictors. However, when this variable was included it was significant (adjusted odds ratio = 3.0, 95% confidence interval = 1.6, 5.7, $P < .001$), and the other significant predictors remained significant with the exception of not identifying a regular doctor ($P = .07$).

TABLE 2—Parental Knowledge and Attitudes and Their Associations with Delayed Immunization of 13-Month-Olds (n = 530): Northern California Kaiser Permanente Medical Care Program, 1992

	No. (%)	Relative Risk of Delayed Immunization[a]	95% CI	P[b]
Late for a previous shot by a month or more (by parent's report)				
Yes	99 (19)	2.6	1.7, 4.1	<.001
No	421 (80)	...	...	...
Don't know	10 (2)	...	...	...
Reason for being late for previous shot				
Child was sick	31 (31)	...	...	...
Appointment was unavailable	13 (13)	...	...	...
Too busy	7 (7)	...	...	...
Didn't know it was due	3 (3)	...	...	...
Forgot	3 (3)	...	...	...
Other[c]	42 (42)	...	...	...
Did not know when next shot was due	189 (36)	2.2	1.4, 3.3	<.001
Did not know when next well-child visit was due	149 (28)	1.6	1.0, 2.5	.06
Ever hesitated to have a previous shot	33 (6)	1.7	0.9, 3.5	NS
Ever had a vaccine reaction that caused worry	60 (11)	0.8	0.3, 1.7	NS
Amount parent worries about risks of shots				.02
A great deal	35 (7)	...	...	...
A moderate amount	111 (21)	1.0	0.3, 3.6	...
A little	215 (41)	1.4	0.4, 4.3	...
Not at all	169 (32)	2.0	0.7, 6.4	...
Amount parent would worry if child were late for a vaccine				NS
A great deal	314 (60)	1.5	0.8, 2.8	...
A moderate amount	126 (24)	...	...	...
A little	65 (12)	2.1	1.0, 4.5	...
Not at all	23 (4)	2.0	0.7, 5.7	...

Note. CI = confidence interval; NS = not significant.

[a]Relative risk is expressed in relation to the baseline categories: not late for a previous shot, knew when next shot or well-child visit was due, never hesitated to have a previous shot, never had a vaccine reaction that caused worry, worries a great deal about risks of shots, and would worry a moderate amount if child were late for a vaccine.

[b]The chi-square test was used for categorical variables. The Wilcoxon rank-sum test was used for ordinal variables (amount parent worries about risks of shots, amount parent would worry if child were late for a vaccine).

[c]Other reasons parents gave for being late for shots included family emergencies, lapses in health insurance coverage, the regular doctor's going on vacation, and rescheduling of appointments.

TABLE 3—Logistic Regression Analysis of Predictors of a Delay of 90 Days or More in Measles-Mumps-Rubella Immunization: Northern California Kaiser Permanente Medical Care Program, 1992

	Adjusted Odds Ratio	95% Confidence Interval	P
Black race	2.0	0.9, 4.3	NS
Asian race	1.6	0.8, 3.3	NS
Latino race/ethnicity	1.1	0.5, 3.4	NS
Number of children in family	1.4	1.1, 1.8	.007
How far in advance previous appointment was made[a]	0.7	0.5, 1.0	NS
No regular doctor by parent's report	2.9	1.0, 8.6	.05
Didn't know when next shot was due	2.0	1.2, 3.5	.01
Amount parent worries about risks of shots[b]	0.7	0.6, 0.8	.03

[a]Ordinal variable. 1 = less than 1 month, 2 = 1 to 2 months, 3 = more than 2 months. Thus, having made the last appointment farther in advance was associated with a lower risk of delayed immunization.
[b]Ordinal variable. 1 = not at all, 2 = a little, 3 = a moderate amount, 4 = a great deal. Thus, worrying more about the risks of vaccines was associated with lower rates of delayed immunization.

Risk Prediction Based on Computerized Data

Two variables available from traditional computerized databases—not having a regular physician assigned and not having made at least three well-child visits during the first 7 months of life—were used as predictors of delayed MMR immunization. Having either of these risk factors identified children who had delayed immunization with a sensitivity of 41% and a specificity of 75%. Thus, fewer than half of the children who would be late for the MMR immunization could be identified in advance by means of information from existing databases.

Follow-Up Survey

Of the 69 families identified by the immunization tracking system as 90 or more days late for the MMR, 43 had follow-up interviews. Two children were reportedly immunized outside KPMCP, one in Mexico and one at a public clinic. Nine parents said a shot had been given at KPMCP, but there was no record of these shots in the written chart or on the tracking system. Three children had received the MMR after 18 months of age.

Twenty-nine parents said their child had not received a vaccination in the past 3 months or that they did not know. Sixteen of these said they had been aware the shot was due and 12 said they had not. The main reason cited for delay was not knowing the shot was due (n = 10), illness of the child (n = 2), and being too busy or forgetting (n = 4). Eight parents cited other reasons, including difficulty in taking time off from work and expecting reminders in the mail.

Discussion

This study shows that financial access to preventive care does not guarantee timely childhood immunization. Although prompt immunization rates are higher among KPMCP children than among the general population, one in eight children enrolled in KPMCP was at least 3 months late for the MMR vaccination.

This study suggests that managed care settings should attempt to better inform parents of when immunizations are due. More than one third of parents of 13-month-olds in this study did not know when their child's next shot was due, and these families were twice as likely as others to be late for the MMR. These findings support two interventions: (1) improving the written information handed out to parents at visits to highlight when immunizations are due and (2) reminding families when immunizations are due via letters or telephone calls.

Advance outreach efforts in managed care settings may be difficult; variables from existing computerized databases could not accurately predict which children would have delayed immunization in this study. However, immunization tracking systems should at least enable providers to promptly remind families who have already missed an immunization. An automated telephone reminder system has proven cost-effective when used with an immunization tracking system in the general population.[12]

This study underscores the importance of continuity of health care, in that families who did not identify a regular doctor or nurse-practitioner were almost three times as likely to be late for the MMR immunization. This result supports evidence from other studies, which suggests that the ability of patients to identify a primary care provider enhances the quality of health care.[13–16] The study did not find an association between copayment amounts and delayed immunization; previous studies have reached divided conclusions on this question.[17,18]

The relatively high immunization rates in this population may be explained, at least in part, by good financial access to a comprehensive health care system that covered immunizations. This study is unique in controlling for financial access while prospectively evaluating nonfinancial predictors. Education, income, and language were not associated with delayed immunization. Families with more children were more likely to have delayed immunization; this finding was similar to that of a previous study.[8] In the general population, children of minority races are at higher risk for delayed immunization.[19] In the present study, Black race was associated with delayed immunization, but the association was not statistically significant after other potentially mediating variables, such as knowledge of when the shot was due, ability to identify a regular doctor, and family size, were controlled.

We found no association between most parental attitudes toward vaccination and subsequent delay in immunization. Unexpectedly, parents who worried more about the risks of shots were actually less likely than others to be late, perhaps because their worrying reflected a generalized anxiety about health that could be associated with a higher likelihood of seeking preventive services.

This study included families of diverse races and educational levels. However, it was limited by the ineligibility of 27% and the unreachability of 9% of the patients selected for attempted interviews. Hard-to-contact respondents may have been more likely to be non-White[20] or to have recently moved or changed insurance plans. This could have biased the study against identifying these characteristics as predictors of delayed immunization. The finding that 24% of the children experienced gaps in KPMCP insurance between 13 and 18 months of age demonstrates the challenge of devel-

oping integrated immunization tracking systems, which will need to coordinate records as families change providers and insurance plans.

We conclude that delays in childhood immunization and gaps in parent understanding of immunization requirements occur even among families with good financial access to health care. Financing reform should improve access to immunizations for some children. Among children with good financial coverage, more work is needed on interventions to better inform parents of when immunizations are due. □

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References

1. Williams BC. Immunization coverage among preschool children: the United States and selected European countries. *Pediatrics.* 1990;86:1052–1055.
2. National Vaccine Advisory Committee. The measles epidemic. *JAMA.* 1991;266: 1547–1552.
3. Freed GL, Katz SL. The comprehensive childhood immunization act of 1993: toward a more rational approach. *N Engl J Med.* 1993;329:1957–1960.
4. Lopreiato JO, Ottolini MC. Does universal access to care guarantee immunization compliance? *Am J Dis Child.* 1993;147:447. Abstract.
5. Marwick C. Improving preschool immunization levels proving more complex than simply providing vaccines. *JAMA.* 1993;269: 1480–1481.
6. Fielding JE, Cumberland WG, Pettitt L. Immunization status of children of employees in a large corporation. *JAMA.* 1994;271: 525–530.
7. Marks JS, Halpin TJ, Irvin JJ, Johnson DA, Keller JR. Risk factors associated with failure to receive vaccinations. *Pediatrics.* 1979;64:304–309.
8. Bobo JK, Gale JL, Thapa PB, Wassilak SGF. Risk factors for delayed immunization in a random sample of 1163 children from Oregon and Washington. *Pediatrics.* 1993;91:308–314.
9. Rodewald LE, Szilagyi PG, Humiston SG, et al. Factors associated with undervaccination of preschool-age children: a case–control study. *Pediatr Res.* 1993;33:122A. Abstract.
10. Dietz VJ, Zell ER, Stevenson J. Defining delayed immunization. *Pediatr Infect Dis J.* 1993;12:353–354. Letter.
11. Varasso DA, Redlener I. Defining delayed immunization. *Pediatr Infect Dis J.* 1992; 897. Letter.
12. Dini E. Informing parents using registries and reminders: the Georgia Autodialer Study. Presented at the Institute of Medicine Workshop on Overcoming Barriers to Immunization; December 8–9, 1993; Washington, DC.
13. Alpert JJ, Robertson LS, Kosa J, Heagarty MC, Haggerty RJ. Delivery of health care for children: report of an experiment. *Pediatrics.* 1976;57:917–930.
14. Becker MH, Drachman RH, Kirscht JP. Predicting mothers' compliance with pediatric medical regimens. *J Pediatr.* 1972;81: 843–854.
15. Charney E, Bynum R, Eldredge D, et al. How well do patients take oral penicillin? A collaborative study in private practice. *Pediatrics.* 1967;40:188–195.
16. Wasson JH, Sauvigne AE, Mogielnicki P, et al. Continuity of outpatient medical care in elderly men. *JAMA.* 1984;252:2413–2417.
17. Cherkin DC, Grothaus L, Wagner EH. The effect of office visit copayments on preventive care services in an HMO. *Inquiry.* 1990;27:24–38.
18. Lurie N, Manning WG, Peterson C, Goldberg GA, Phelps CA, Lillard L. Preventive care: do we practice what we preach? *Am J Public Health.* 1987;77:801–804.
19. Orenstein WA, Atkinson W, Mason D, Bernier RH. Barriers to vaccinating preschool children. *J Health Care Poor Underserved.* 1990;1:315–330.
20. Mishra SI, Dooley D, Catalano R, Serxner S. Telephone health surveys: potential bias from noncompletion. *Am J Public Health.* 1993;83:94–99.